2005 Smooth Brome Monitoring

Introduction

Smooth brome *(Bromus inermi*s) is an exotic graminoid species that has been used for over a century across much of North America as a revegetation grass. Research has shown the species is an aggressive invader of native plant communities under certain conditions. It often invades native grassland communities, replacing the native plant species, reducing biodiversity, and lowering the wildlife habitat value of an area. The grass has been used in the past at the Rocky Flats Environmental Technology Site (Site) for numerous revegetation projects. For the past several years it has been prohibited for use in seed mixtures at the Site. However, numerous locations on the grassland have been invaded by the species and smooth brome circles are common at many locations in the Buffer Zone (BZ). When smooth brome becomes established at a location in a native plant community it typically reproduces vegetatively by underground rhizomes (horizontal underground stem tissue) and grows outwardly in a circle from the point of origin (Figure 1). As the circles expand outwardly the smooth brome out-competes native species for resources and the circle usually becomes a solid stand of smooth brome. To evaluate the effectiveness of weed control efforts on smooth brome, the following investigation was conducted. The purpose of this monitoring effort is three-fold:

- Determine the rate of expansion of smooth brome circles.
- Evaluate the effectiveness of different control methods to kill smooth brome circles.
- Evaluate the effectiveness of revegetating dead smooth brome circles with native plant species.

Methods

The investigation was conducted in the south BZ at the Site, where a large number of isolated smooth brome circles of varying sizes had invaded the native mesic mixed grassland. The study area was situated on a north-east facing slope. Each of the smooth brome circles that was evaluated during the investigation was mapped using a GPS unit in the field to assist with future relocation of the circles (Figure 2).

In 2003, a total of 12 smooth brome circles in the BZ were selected for evaluating expansion rates. Both large and small smooth brome circles were selected for measurement to determine if size made any difference in expansion rates. Small circles were defined as those that were initially less than 4 m^2 in size. Large circles were those initially larger than 30 m^2 in size. A piece of rebar was staked in the center of each circle. Four measurements of the radius were made and marked with a metal tag on the edge of each circle, from the center rebar to the most distant smooth brome culm (stem) along the edge of the circle in approximately each of the four cardinal directions. Distances were measured to the nearest centimeter. Measurements were typically made to the farthest culm within a meter or so of the original metal tag. The mean radius for each circle was determined and the area of the circle calculated based on the mean radius. Expansion rate measurements were made in the fall of 2003, and spring and fall of 2004, and 2005.

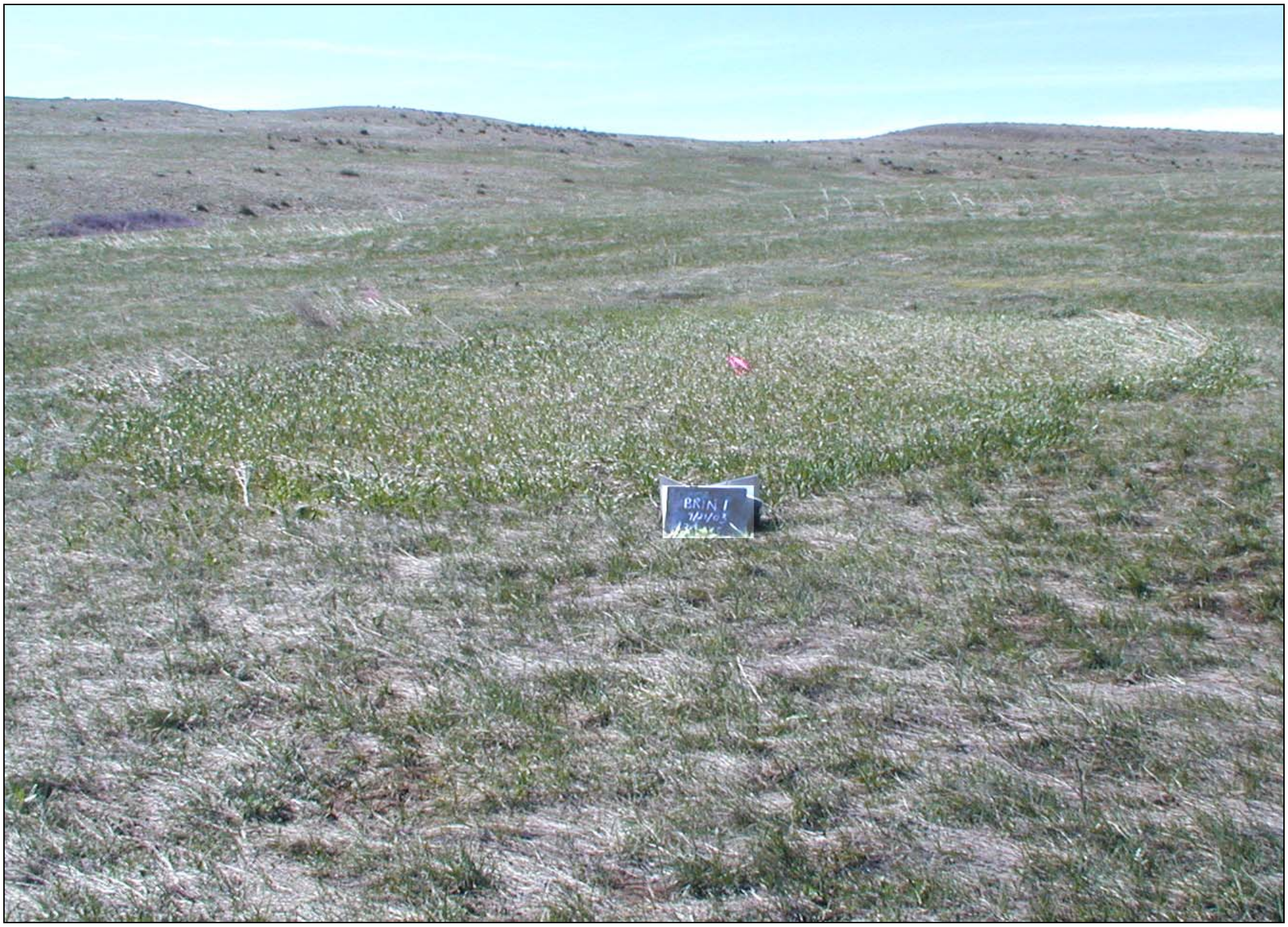
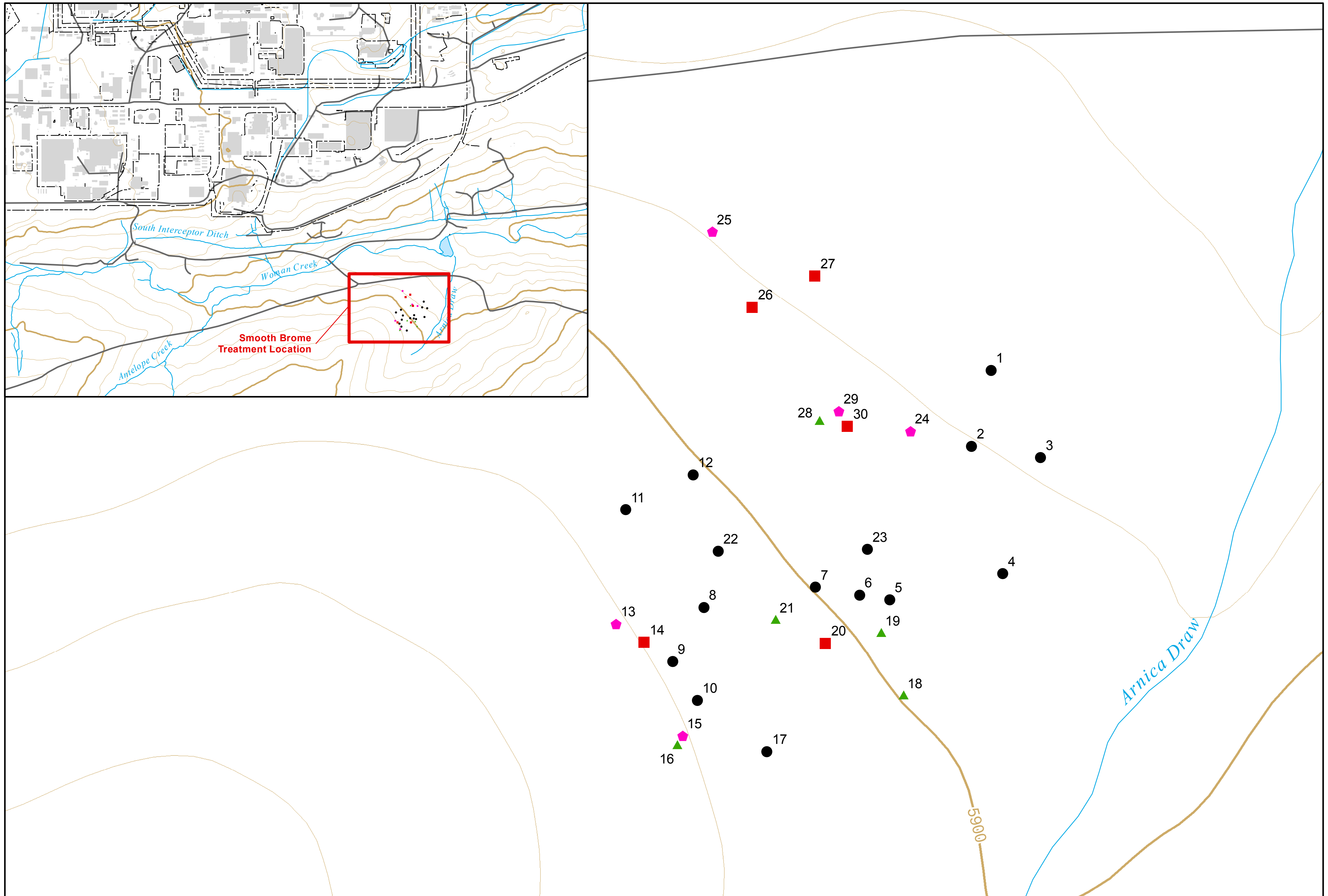


Figure 1. Smooth brome circle on native grassland.



Smooth Brome Weed Control Locations

Figure 2

LEGEND

TREATMENT

- Measured only
- Covered Only
- Sprayed Only
- Sprayed/Covered

STANDARD FEATURES

- Fence
- Roads
- Former building or other structure
- Streams, ditches, or other drainage features
- Lake or pond
- Topographic contour (20-foot interval)
- Topographic contour (100-foot interval)

DATA SOURCE BASE FEATURES:
Buildings, fences, hydrography, roads and other structures from 1994 aerial fly-over data captured by EG&G RSL, Las Vegas. Digitized from the orthophotographs, 1/95.

Scale = 1:1,200
1 inch represents 100 feet

100 50 0 100
Scale in Feet

N

State Plane Coordinate System
Colorado Central Zone
North American Datum of 1927

(Inset scale = 1:15,840)

U.S. DEPARTMENT OF ENERGY GRAND JUNCTION, COLORADO	Work Performed by **S.M. Stoller Corporation** Under DOE Contract No. DE-AC01-02GJ79491
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To evaluate the effectiveness of control methods for smooth brome, three treatments were used including; shading, glyphosate (Roundup®) applications, and glyphosate/shading applications. A total of 15 smooth brome circles were treated (five for each treatment type). The shading treatment was accomplished by placing black plastic sheeting over a smooth brome infestation for an entire growing season (late April/early May through November; Figure 3). Prior to placement of the black plastic sheeting, the diameter of the smooth brome circle was measured on two perpendicular lines running in the cardinal directions. The edges of the circle where the measurements were made were tagged with nails and metal tags as described above. The black plastic extended a minimum of 0.5 m beyond the edge of the smooth brome circle. The black plastic was held in place using metal stakes/staples and rocks. The plastic was placed on the ground in late April/early May 2003 and removed in November 2003.

Glyphosate applications were applied to selected brome circles in early May (both the glyphosate-only and the glyphosate/shade treatments). Good coverage of the herbicide was applied to the green culms (stems) of smooth brome using a backpack sprayer with glyphosate mixed at a rate of 6 oz. (18% concentration glyphosate)/gallon of water. Some of the glyphosate-only treatment circles received additional spot treatments of herbicide during summer 2003 if it appeared that not all the smooth brome had been killed.

The glyphosate/shading treatment consisted of a preliminary application of the herbicide in the spring, followed by shading for the remainder of the growing season. The application of glyphosate followed the methods outlined above with the exception that only one application was made prior to shading. After application of the glyphosate, the black plastic was applied as described above. The black plastic was placed on the smooth brome circle the same day as the glyphosate application was made.

After removal of the black plastic from the circles in November 2003, all the circles from each treatment were broadcast seeded with a native seed mix that included western wheatgrass (*Agropyron smithii*), blue grama (*Bouteloua gracilis*), side-oats grama (*Bouteloua curtipendula*), buffalo grass (*Buchloe dactyloides*), green needle grass (*Stipa viridula*), slender wheatgrass (*Agropyron caninum* [*A. trachyplurum*]), and blue flax (*Linum perenne*). The seed was raked to provide better soil/seed contact. Field notes were also made as to the condition of each circle prior to reseeding. Photographs were taken of each smooth brome circle prior to the start of the study and at the end of the season prior to reseeding to document the condition of the circle (Figure 4).

During 2004 and 2005, the plots were revisited three times. In spring and fall, measurements of the expansion rates of the circles were made and photographs were taken. Field notes were made during each visit to document the condition of the treatment plots. Additional glyphosate spot applications were made in 2004 in April and August when smooth brome plants were observed growing in the plots.

In August 2004 and 2005, a list of the plant species found growing within each of the treated circles was recorded. The foliar cover of each species within the circle was recorded using a visual cover class system: 1 <= 5%, 2 = 6-25%, 3 = 26-50%, 4 = 51-75%, 5 => 76%. Midpoints of the cover classes were used for analyses: 1 = 3%, 2 = 15%, 3 = 37.5%, 4 = 62.5%, and 5 = 87.5%.

Figure 3. Finished shaded smooth brome circle. Rocks were used to help keep the black plastic from blowing away.

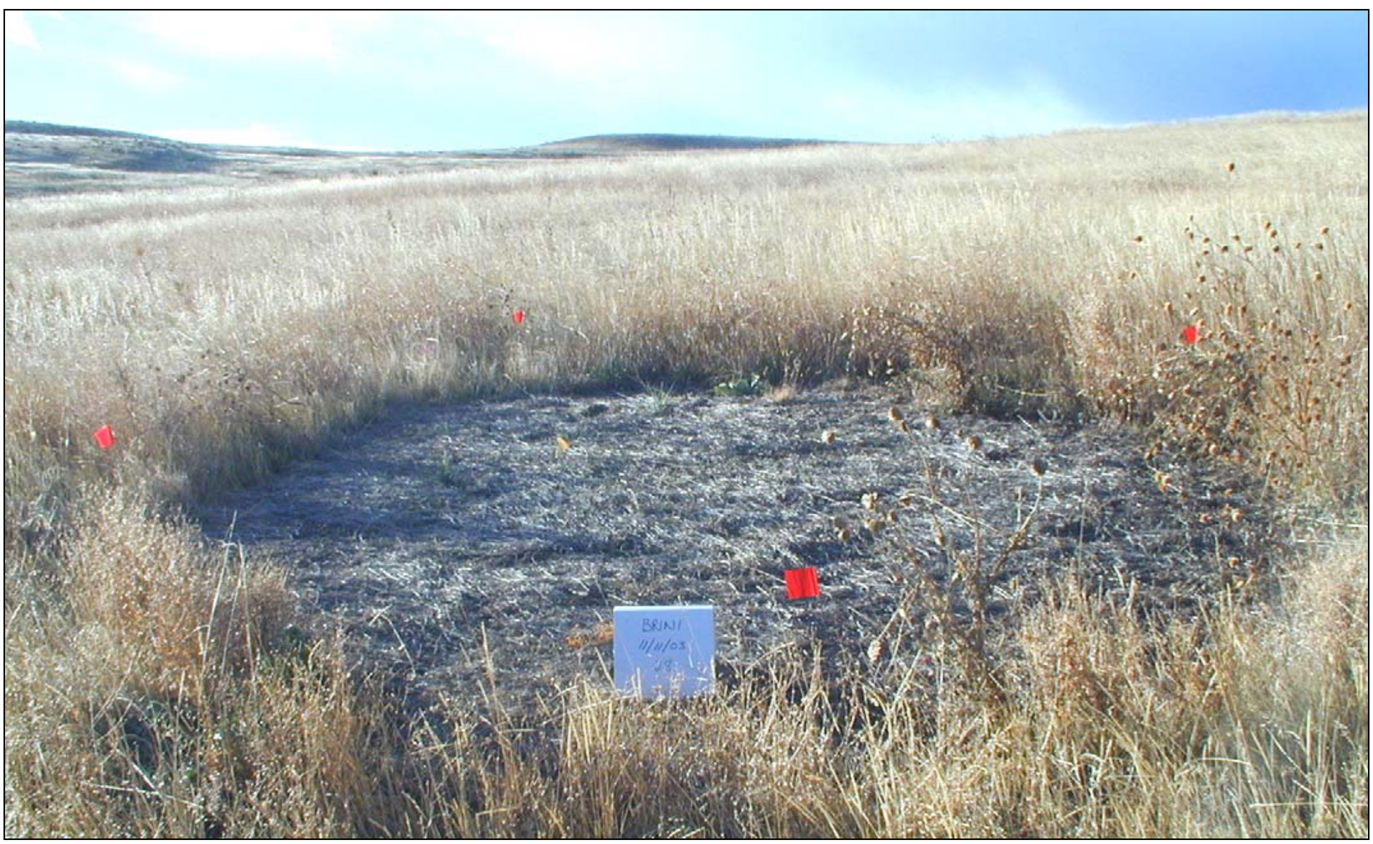

Figure 4. Sprayed circle with dead smooth brome at the end of the growing season in 2003.

Results and Discussion

During 2003, the smooth brome circle expansion data showed little change in the overall size (area or radius) of the brome circles from late April/early May to November (Tables 1 and 2). No difference was observed in the expansion rates of small circles compared to large circles in 2003. The precipitation received from May through October 2003 was only 5 inches compared to the mean of 9.7 inches for the past 14 years at the Site. The lack of precipitation during most of the growing season after the start of the project may have contributed to the lack of increase in the size of the circles.

During the winter of 2003/2004, the area of both small smooth brome circles and large smooth brome circles increased in size (small circle increase = ~48%, large circle increase = ~9%; fall 2003 to spring 2004, Table 1). During 2004, over 15.2 inches of precipitation was received from May through October, three times the amount received in 2003 (5 inches). From spring 2004 to fall 2004 the area of small smooth brome circles increased by ~60% and the large circles increased by 13% (Table 1). Throughout the growing season in 2005, the small circles increased an additional ~24%, whereas the large circles did not change much (Table 1). During 2005, a total of 11.4 inches of precipitation was received from May through November.

Throughout the duration of the investigation (spring 2003 to fall 2005), smaller smooth brome circles have more than tripled in size (208% mean increase; Table 1). The average area of the small circles was originally only 2.1 m^2. After three growing seasons, this had increased to 6.4 m^2. Large circles have increased approximately 35% on average since the outset of the investigation. The average area of the large circles was 73.2 m^2 at the outset, but by fall 2005 this had increased to 99.1 m^2. These large increases over the course of three growing seasons illustrate how quickly and aggressively smooth brome can invade into a native grassland and replace the native species. This is particularly problematic where many circles are present in an area and they can coalesce into larger circles in a short period of time.

The results of the three treatments – spraying (glyphosate-only), shading, and spraying (glyphosate)/shading, showed excellent apparent initial die-off of the smooth brome for all three treatments by fall 2003. In all the circles of each treatment, all the smooth brome appeared dead, in addition to nearly everything else in most of the circles (Figure 4). Although some additional application of glyphosate was required in a few of the uncovered circles to completely kill the smooth brome by fall 2003, the timing of the herbicide application in the spring may have also had a role in the "good kill" of smooth brome that was observed. The glyphosate was applied on May 1 to the sprayed-only plots, at the time when the brome was greening up and little else had started growing. So the herbicide largely affected only the brome. As a result, it was observed in the fall that in several of the glyphosate-only plots, native species such as side-oats grama, western wheatgrass, purple three-awn (*Aristida purpurea* ssp. *robusta*), white aster (*Aster falcatus*), and silky wormwood (*Artemesia dracunculus*) were already coming up and taking advantage of the lack of competition from the smooth brome. These species may not have been actively growing when the herbicide was applied in the early spring, and were thus not impacted by the spraying. One noxious weed species that survived beneath the shaded only circles was musk thistle (*Carduus nutans*). Several rosettes were still alive after the plastic was removed. However, musk thistle was not present under the shaded circles that had been sprayed or in the sprayed-only circles.

Table 1. Smooth Brome Expansion Rates (Area)
Small Circles

	4/21/2003	11/10/2003	5/3/2004	10/8/2004	5/12/2005	11/4/2005	Spring 03 to Fall 03	Fall 03 to Spring 04	Spring 03 to Spring 04	Spring 04 to Fall 04	Spring 03 to Fall 04	Spring 05 to Fall 05	Spring 03 to Fall 05
BRIN Plot #	**Circle Area (sq. meters)**						**% Change**	**% Change**	**% Change**	**% Change**	**% Change**	**% Change**	**% Change**
1	1.4	1.4	2.0	4.6	4.7	5.3	0.0	42.9	42.9	130.0	228.6	12.8	278.6
2	2.9	3.0	4.2	8.6	9.0	10.9	3.4	40.0	44.8	104.8	196.6	21.1	275.9
6	3.8	3.8	5.4	5.7	6.4	6.9	0.0	42.1	42.1	5.6	50.0	7.8	81.6
7	0.7	0.7	1.2	2.2	2.3	2.8	0.0	71.4	71.4	83.3	214.3	21.7	300.0
8	1.0	1.0	1.9	3.3	3.9	4.8	0.0	90.0	90.0	73.7	230.0	23.1	380.0
12	2.7	2.5	3.7	5.0	6.3	7.8	-7.4	48.0	37.0	35.1	85.2	23.8	188.9
Mean	2.1	2.1	3.1	4.9	5.4	6.4	-0.8	48.4	47.2	59.8	135.2	18.1	208.0

Large Circles

	4/21/2003	11/10/2003	5/3/2004	10/8/2004	5/12/2005	11/4/2005	Spring 03 to Fall 03	Fall 03 to Spring 04	Spring 03 to Spring 04	Spring 04 to Fall 04	Spring 03 to Fall 04	Spring 05 to Fall 05	Spring 03 to Fall 05
BRIN Plot #	**Circle Area (sq. meters)**						**% Change**	**% Change**	**% Change**	**% Change**	**% Change**	**% Change**	**% Change**
3	64.4	64.5	69.5	80.3	88.7	82.2	0.2	7.8	7.9	15.5	24.7	-7.3	27.6
4	34.6	35.2	34.3	38.8	55.2	61.7	1.7	-2.6	-0.9	13.1	12.1	11.8	78.3
5	54.0	54.2	61.2	68.0	73.1	74.9	0.4	12.9	13.3	11.1	25.9	2.5	38.7
9	93.6	93.4	101.1	112.7	111.3	119.2	-0.2	8.2	8.0	11.5	20.4	7.1	27.4
10	111.3	110.0	121.9	139.3	156.1	149.9	-1.2	10.8	9.5	14.3	25.2	-4.0	34.7
11	81.1	80.3	90.0	99.9	101.6	106.5	-1.0	12.1	11.0	11.0	23.2	4.8	31.3
Mean	73.2	72.9	79.7	89.8	97.7	99.1	-0.3	9.2	8.9	12.8	22.8	1.4	35.4
Grand Mean	37.6	37.5	41.4	47.4	51.6	52.7	-0.3	10.3	9.9	14.5	25.9	2.3	40.2

Table 2. Smooth Brome Expansion Rates (Radius)
Small Circles

	4/21/2003	11/10/2003	5/3/2004	10/8/2004	5/12/2005	11/4/2005	Spring 03 to Fall 03	Fall 03 to Spring 04	Spring 03 to Spring 04	Spring 04 to Fall 04	Spring 03 to Fall 04	Spring 05 to Fall 05	Spring 03 to Fall 05
BRIN Plot #	**Mean radius (cm)**						**% Change**	**% Change**	**% Change**	**% Change**	**% Change**	**% Change**	**% Change**
1	67.0	67.0	80.5	121.3	122.5	129.8	0.0	20.1	20.1	50.7	81.0	6.0	93.7
2	96.0	98.5	116.3	165.5	169.0	186.5	2.6	18.1	21.1	42.3	72.4	10.4	94.3
6	110.5	110.5	130.8	135.0	142.3	147.7	0.0	18.4	18.4	3.2	22.2	3.8	33.7
7	48.8	47.8	61.0	84.3	86.3	93.8	-2.0	27.6	25.0	38.2	72.7	8.7	92.2
8	57.8	55.5	78.5	102.5	112.0	123.0	-4.0	41.4	35.8	30.6	77.3	9.8	112.8
12	92.8	89.3	109.0	126.8	142.0	157.7	-3.8	22.1	17.5	16.3	36.6	11.1	69.9
Mean	78.8	78.1	96.0	122.6	129.0	139.8	-0.9	22.9	21.8	27.7	55.5	8.3	77.3

Large Circles

	4/21/2003	11/10/2003	5/3/2004	10/8/2004	5/12/2005	11/4/2005	Spring 03 to Fall 03	Fall 03 to Spring 04	Spring 03 to Spring 04	Spring 04 to Fall 04	Spring 03 to Fall 04	Spring 05 to Fall 05	Spring 03 to Fall 05
BRIN Plot #	**Mean radius (cm)**						**% Change**	**% Change**	**% Change**	**% Change**	**% Change**	**% Change**	**% Change**
3	452.8	453.3	470.3	505.5	531.3	511.5	0.1	3.8	3.9	7.5	11.6	-3.7	13.0
4	332.0	334.5	330.3	351.3	419.3	443.3	0.8	-1.3	-0.5	6.4	5.8	5.7	33.5
5	414.5	415.3	441.5	465.3	482.3	488.3	0.2	6.3	6.5	5.4	12.3	1.2	17.8
9	545.8	545.3	567.3	599.0	595.3	616.0	-0.1	4.0	3.9	5.6	9.7	3.5	12.9
10	595.3	591.8	623.0	666.0	705.0	690.8	-0.6	5.3	4.7	6.9	11.9	-2.0	16.0
11	508.0	505.5	535.3	564.0	568.8	582.3	-0.5	5.9	5.4	5.4	11.0	2.4	14.6
Mean	474.7	474.3	494.6	525.2	550.3	555.4	-0.1	4.3	4.2	6.2	10.6	0.9	17.0
Grand Mean	276.8	276.2	295.3	323.9	339.7	347.6	-0.2	6.9	6.7	9.7	17.0	2.3	25.6

Initial results at the end of 2003 suggested that glyphosate-only worked just as well as shading-only or glyphosate/shading (Figure 5). However, by spring 2004, differences were apparent between the treatments. The glyphosate-only treatment had an 80% frequency of smooth brome returning in the plots, whereas the shaded-only treatment showed a 40% return of smooth brome. By fall 2004, the shaded-only treatment had declined to 20% return of smooth brome. The results for 2005 were the same as the October 2004 data for the glyphosate-only and glyphosate/shaded plots. The shaded-only plots with smooth brome present rose to 40% in 2005, the same percentage as found in the glyphosate/shaded plots. From a cost standpoint however, the shaded plots would still be the most effective treatment of those tested in terms of materials and labor.

A key question regarding the long-term effectiveness of any of these treatments revolves around the issue of the seed bank. Although the use of different combinations of herbicides and/or shading may effectively kill the smooth brome initially at a location, if the seed bank is prolific in re-establishing a circle, then the effectiveness of the treatments under evaluation may be of little consequence without a long-term perspective on control at each smooth brome circle. How significant a role the seed bank plays remains to be seen.

How quickly and abundantly the native species are able to establish from the seed sown within the circles in the fall of 2003 is also a question of importance. Isolated circles of smooth brome were chosen for this investigation because it was thought that if the smooth brome in a circle surrounded by native grassland could be killed, the native community may be able to heal itself (with some help from the seeding of native species). An unpublished study conducted in the City of Boulder Mountain Parks in a stand of solid smooth brome showed that if smooth brome was present around the edges of a shaded plot, it continued to invade beneath the edges of the black plastic and weed barrier (Nelson and Armstrong, 2004). One of the goals of this present study was to determine whether the native grassland could re-establish in a previous circle of brome (with some help from reseeding).

Observations of the establishment of the seeded native species shows mixed success thus far. Of the seven species seeded in fall 2003, six were found growing in the treated circles in August of 2004 and again in August of 2005 (Table 3). Only buffalo grass has not been found growing in any of the treated circles. This is likely due to the profusion of early successional "weedy" species that initially established on the disturbed plots. The density and height of these plants has likely inhibited the germination and establishment of this shortgrass prairie species. Slender wheatgrass (a seeded species) continues to dominate the treated circles with a mean foliar cover ranging from 19% to 73% depending on the treatment (Table 3). The best establishment of slender wheatgrass continues to be found in the shaded-only and sprayed/shaded plots. Interestingly, blue grama, side-oats grama, and green needle grass, have only done well so far in the glyphosate-only treatment, which would suggest that perhaps the plants observed in 2004 were not from seed, but rather pre-existing plants that had not been affected by the herbicide application in spring 2003 because they were not growing at the time of the application. Some blue grama and green needle grass were observed beginning to establish in the shaded only and glyphosate/shaded plots, respectively in 2005. Common sunflower (*Helianthus annuus*; a native), an early successional species which dominated the forb component of all the treated plots in 2004, did not even occur in the plots in 2005. Alyssum (*Alysum minus*: a non-native), another abundant early successional species in 2004, decreased substantially in the glyphosate only plots in 2005, while increasing slightly in the shaded and glyphosate/shaded plots. Japanese brome (*Bromus japonicus*; a non-native), increased in all three treatments with the greatest increase occurring in the glyphosate only plots. Although smooth brome was present in 40% of

Figure 5. Frequency (%) Of Plots Infested With Smooth Brome

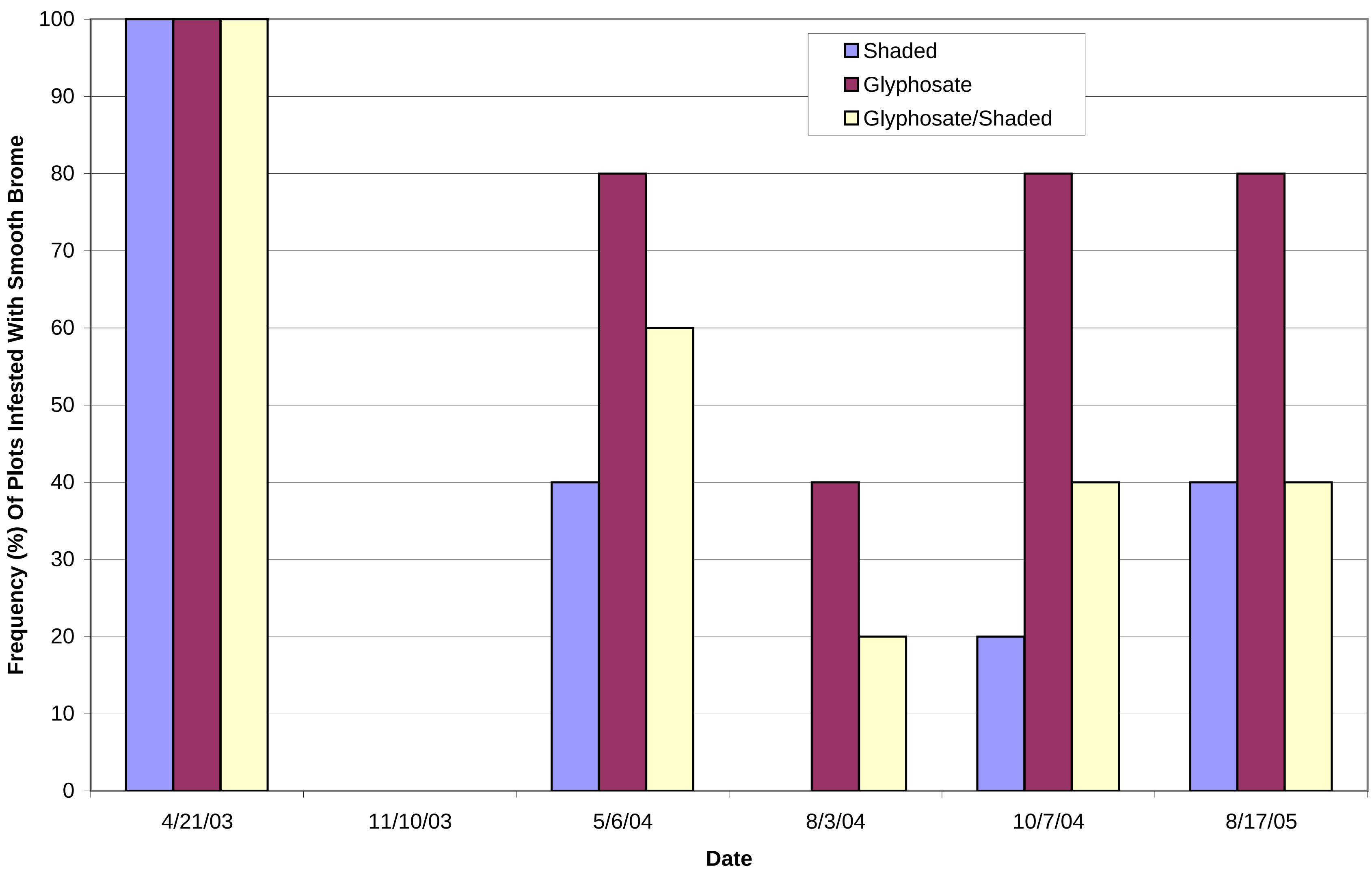

Table 3. Smooth Brome Plot Species Richness/Cover Summary for 2004 and 2005

					BRIN1 Plot Number																																			
					Shaded Only												Glyphosate Only												Glyphosate/Shaded											
					2004	2005	2004	2005	2004	2005	2004	2005	2004	2005	2004	2005	2004	2005	2004	2005	2004	2005	2004	2005	2004	2005	2004	2005	2004	2005	2004	2005	2004	2005	2004	2005	2004	2005	2004	2005
Scientific Name	**Speccode**	**Growth Form**	**Native**	**Cool/Warm Season**	**14**	**14**	**20**	**20**	**26**	**26**	**27**	**27**	**30**	**30**	**X**	**X**	**16**	**16**	**18**	**18**	**19**	**19**	**21**	**21**	**28**	**28**	**X**	**X**	**13**	**13**	**15**	**15**	**24**	**24**	**25**	**25**	**29**	**29**	**X**	**X**
Alyssum minus (L.) Rothmaler var. micranthus (C. A. Mey.) Dudley	ALMI1	F	N			37.5		3	3	3	3	3	15	15	4.2	12.3	3	15	37.5	3	15		37.5	3	37.5	3	26.1	4.8	3	15	3	15	3	3		3	3	3	2.4	7.8
Anthemis cotula L.	ANCO1	F	N												0	0											0	0									3		0.6	0
Arabis glabra (L.) Bernh.	ARGL1	F	N						3	3					0.6	0.6											0	0								3			0	0.6
Camelina microcarpa Andrz. ex DC.	CAMI1	F	N				15		3		3	3			4.2	0.6									3		0.6	0					3		3		3		1.8	0
Carduus nutans L. ssp. macrolepis (Peterm.) Kazmi	CANU1	F	N				3	3	15	15	3	15	3	3	4.8	7.2			15	37.5	3	15	3	3	3	15	4.8	14.1	3	3		3	15	15	15	15	3	15	7.2	10.2
Centaurea diffusa Lam.	CEDI1	F	N						3	3				3	0.6	1.2	3	37.5			3	3		3	3		1.8	8.7				3		3		3			0	1.8
Chenopodium album L.	CHAL1	F	N		3		3		3		3		3		3	0									3		0.6	0					15		3		3		4.2	0
Cirsium arvense (L.) Scop.	CIAR1	F	N						3						0.6	0									3		0.6	0								3			0	0.6
Erodium cicutarium (L.) L'Her.	ERCI1	F	N												0	0											0	0	3										0.6	0
Lactuca serriola L.	LASE1	F	N		3		15		3	3	15		15		10.2	0.6	3		15		15		3		3		7.8	0	3				3		3		3		2.4	0
Linaria dalmatica (L.) Mill.	LIDA1	F	N						3	3	3	3			1.2	1.2	3	3				3		3			0.6	1.8	3		3	3							1.2	0.6
Melilotus alba Medic.	MEAL1	F	N							3					0	0.6											0	0								3			0	0.6
Melilotus officinalis (L.) Pall.	MEOF1	F	N												0	0											0	0						3					0	0.6
Salsola iberica Senn. & Pau.	SAIB1	F	N								3				0.6	0											0	0							3				0.6	0
Scorzonera laciniata L.	SCLA1	F	N												0	0		3									0	0.6											0	0
Sisymbrium altissimum L.	SIAL1	F	N										3		0.6	0					3		3		3		1.8	0			3		3		3				1.8	0
Taraxacum officinale Weber	TAOF1	F	N												0	0								3			0	0.6											0	0
Thlaspi arvense L.	THAR1	F	N										3		0.6	0									3		0.6	0			3		3		3		3		2.4	0
Tragopogon dubius Scop.	TRDU1	F	N											3	0	0.6	3	3		3	3	3	3	3	3	3	2.4	3				3							0	0.6
Verbascum blattaria L.	VEBL1	F	N												0	0			3		3	3					1.2	0.6		3				3					0	1.2
Verbascum thapsus L.	VETH1	F	N		3	3				3	3	3			1.2	1.8					3					3	0.6	0.6					3	3		3			0.6	1.2
Achillea millefolium L. ssp. lanulosa (Nutt.) Piper	ACMI1	F	Y												0	0										3	0	0.6											0	0
Artemisia dracunculus L.	ARDR1	F	Y												0	0									3	3	0.6	0.6		3									0	0.6
Artemisia frigida Willd.	ARFR1	F	Y												0	0								3			0	0.6											0	0
Artemisia ludoviciana Nutt. var. ludoviciana	ARLU1	F	Y		3	15				3				3	0.6	4.2		3	3	3		3	3	3		3	1.2	3	15	3		3	3			3	3	3	4.2	2.4
Aster falcatus Lindl.	ASFA1	F	Y												0	0		3						3	3	3	0.6	1.8	3										0.6	0
Asclepias pumila (Gray) Vail	ASPU1	F	Y												0	0											0	0							3				0.6	0
Calochortus gunnisonii S. Wats.	CAGU1	F	Y											3	0	0.6											0	0											0	0
Chrysopsis villosa Pursh.	CHVI1	F	Y												0	0											0	0	3										0.6	0
Comandra umbellata (L.) Nutt.	COUM1	F	Y							3		3			0	1.2		3			3		3	3			1.2	1.2				3							0	0.6
Descurainia pinnata (Walt.) Britt.	DEPI1	F	Y				3				3				1.2	0											0	0	3		3		3		3		3		3	0
Gaura coccinea Pursh.	GACO1	F	Y							3					0	0.6											0	0											0	0
Grindelia squarrosa (Pursh.) Dun.	GRSQ1	F	Y												0	0	3										0.6	0			3								0.6	0
Gutierrezia sarothrae (Pursh.) Britt. & Rusby	GUSA1	F	Y												0	0		3									0	0.6											0	0
Helianthus annuus L.	HEAN1	F	Y		3		3		37.5		62.5		3		21.8	0	15		37.5		62.5		37.5		15		33.5	0	3		15		15		37.5		15		17.1	0
Linum perenne L. var. lewisii (Pursh.) Eat. & Wright	**LIPE1**	F	Y			3	3	3	3	3	3	3		3	1.8	3	3	3	3	3	3	3	3	15	3	15	3	7.8	3		3	3	3	3	3	3		3	2.4	2.4
Physaria vitulifera Rydb.	PHVI1	F	Y												0	0							3				0.6	0											0	0
Polygonum ramosissimum Michx.	PORA1	F	Y												0	0					3		3				1.2	0	3										0.6	0
Psoralea tenuiflora Pursh.	PSTE1	F	Y						3	3	3	3			1.2	1.2			3		3		3	3	3		2.4	0.6	15	3	3	3			3	3			4.2	1.8
Ratibida columnifera (Nutt.) Woot. & Standl.	RACO1	F	Y							3					0	0.6				3		3			3	3	0.6	1.8				3							0	0.6
Silene antirrhina L.	SIAN1	F	Y							3					0	0.6									3		0.6	0											0	0
Sphaeralcea coccinea (Pursh.) Rydb.	SPCO1	F	Y		15										3	0					3						0.6	0	3								3		1.2	0
Tradescantia occidentalis (Britt.) Smyth	TROC1	F	Y											3	0	0.6											0	0											0	0
Vicia americana Muhl. ex Willd.	VIAM1	F	Y								3				0.6	0											0	0											0	0
Bromus inermis Leyss. ssp. inermis	BRIN1	G	N	C								3		3	0	1.2				3		3	3	3	3	15	1.2	4.8			3					3		3	0.6	1.2
Bromus japonicus Thunb. ex Murr.	BRJA1	G	N	C	3	3	3	3	3	3	3	3	3	15	3	5.4	15	15	3	15	15	15	15	37.5	3	62.5	10.2	29	3	3	15	3	3	3	3	3	15	37.5	7.8	9.9
Bromus tectorum L.	BRTE1	G	N	C			3	3							0.6	0.6											0	0											0	0
Poa compressa L.	POCO1	G	N	C											0	0											0	0							3				0.6	0
Poa pratensis L.	POPR1	G	N	C				3						3	0	1.2											0	0											0	0
Agropyron caninum (L.) Beauv. ssp. majus (Vasey) C. L. Hitchc.	**AGCA1**	G	Y	C	3	3	37.5	62.5	37.5	62.5	37.5	87.5	37.5	37.5	30.6	50.6	3	3	3	37.5	15	15	15	37.5	15	3	10.2	19.2	37.5	62.5	37.5	87.5	37.5	87.5	62.5	87.5	62.5	37.5	47.5	72.5
Agropyron smithii Rydb.	**AGSM1**	G	Y	C	3	15	15	3	3		3		3	3	5.4	4.2			3	3	3	3	3	3	3		2.4	1.8		3	3		3		3		3	3	2.4	1.2
Aristida purpurea Nutt. var. robusta (Merrill) A. Holmgren & N. Holmgr	ARLO1	G	Y	C											0	0	3	15									0.6	3											0	0
Koeleria pyramidata (Lam.) Beauv.	KOPY1	G	Y	C											0	0						3		3		3	0	1.8											0	0
Stipa viridula Trin.	**STVI1**	G	Y	C											0	0		3			3		3	3			1.2	1.2		3									0	0.6
Bouteloua curtipendula (Michx.) Torr.	**BOCU1**	G	Y	W											0	0	3		3	3	3		3				2.4	0.6											0	0
Bouteloua gracilis (H. B. K.) Lag ex Griffiths	**BOGR1**	G	Y	W				3						3	0	1.2			3		3	3	3	3	3		2.4	1.2											0	0
Rosa arkansana Porter	ROAR1	S	Y												0	0	3	15									0.6	3			3	3							0.6	0.6

X = Mean (arithmetic)

the shaded and glyphosate/shaded plots and in 80% of the glyphosate-only plots in 2005, and although the cover of the species is still quite small (1.2% to 4.8% in 2005), it has increased since 2004 (Table 3). Thus if left alone, the smooth brome will eventually continue to expand, as the earlier data show.

The results of the study show that a single application of any of the treatments used here will not eradicate smooth brome from a former circle. Whether from the seed bank or unkilled root systems, smooth brome has returned in all of the treatments applied during this study, albeit in small amounts thus far. Continued observation and treatment of the small amounts of returning smooth brome will be required for many years to give the native species a good chance at re-establishing the native prairie in the former smooth brome circles. Additional seeding of native species may also be required to help the native species get established.

Summary

An investigation was begun to evaluate potential weed control techniques for smooth brome, a non-native grass. Growth rates of smooth brome circles showed a 208% increase small smooth brome circles (< 4 m^2 in size) and a 35% increase in large smooth brome circles (>30 m^2 in size) over three growing seasons. Above average moisture during two of the three growing seasons probably helped fuel the increase in size, but the data show how quickly the smooth brome can invade into native grasslands.

The use of glyphosate, glyphosate/shading, and shading alone, were evaluated as treatments to kill smooth brome. All three treatments showed initial good success in killing smooth brome however, by the second and third growing season smooth brome was present at some level in all the treatments. The least effective control was observed in the glyphosate-only treatment (80% return). The shading and glyphosate/shading treatments both had 40% return rates after the third growing season. Smooth brome foliar cover in all treatments was less than 5% after the third growing season. Some establishment of the seeded native species has been observed. It is apparent, however, that continued observation and treatment of the returning smooth brome will be necessary for many years after the initial treatments to prevent the re-establishment of the smooth brome circles and to give the native species a good chance of establishing.

References

Nelson, J.K. and A. Armstrong. 2004. Unpublished data from smooth brome study in Chautauqua Meadow, City of Boulder Open Space and Mountain Parks, Boulder, CO.